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Parasites of Some Fish Introduced into an Arizona Reservoir, with Notes on Introductions

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ABSTRACT: Of 6 species of introduced fishes examined from Lake Mohave, an impoundment of the Colorado River in northwestern Arizona, 5 yielded 8 species of metazoan parasites during March 1994. *Atractolytocestus huronensis* infected *Cyprinus carpio*; *Corallobothrium fimbriatum* and *C. giganteum* infected *Ictalurus punctatus*; *Proteocephalus ambloplitis* adults and plerocercoids infected *Micropterus salmoides* and *Lepomis macrochirus*, respectively; *Ornithodiplostomum ptychocheilus* and *Posthodiplostomum minimum* metacercariae infected the liver of *L. macrochirus*; *Hysterothylacium* sp. larvae infected the body cavity of *M. salmoides, I. punctatus, C. carpio,* and *Morone saxatilis*; and *Myzobdella lugubris* infected *I. punctatus*. All records, except that of *O. ptychocheilus,* are new for the state of Arizona. Fish were most heavily infected with *Hysterothylacium* sp., which also infected and killed 2 native Gila topminnows, *Peociliopsis o. occidentalis*. The introduction of fishes and their parasites are discussed.
KEY WORDS: fish parasites, Lake Mohave, Arizona, introductions.

Natural and artificial aquatic habitats of Arizona are shared by a depauperate indigenous fish fauna of about 28 freshwater species and an equal but increasing number of nonindigenous fishes (at least 30 taxa are naturalized; Minckley, 1973, 1982, 1991) introduced from a wide variety of sources. Only a few fish populations, native or nonnative, have been examined in any detail for parasites. Most records are incidental in reports on other aspects of fish biology (e.g., for razorback sucker, *Xyrauchen texanus* (Abbott), Minckley, 1983; Minckley et al., 1991). Exceptions for native fishes include reports by James (1968; a copepod, *Lernaea*), Amin (1969b; helminths of suckers), Mpoame (1982) and Mpoame and Rinne (1983) (protozoans, helminths), Mpoame and Landers (1981; *Ophiotaenia critica,* a new species from Colorado squawfish, *Ptychocheilus lucius* Girard), Mpoame and Rinne (1984; endemic trouts, *Onchorhynchus apache, O. gilae* helminths), and Heckmann et al. (1986; woundfin minnow, *Plagopterus argentissimus* Cope helminths). In other relevant works, Flagg (1980, 1982) has reviewed protozoan and metazoan parasites of native fishes in the Upper Colorado Basin, Utah–Colorado. Reports on parasites of introduced species are those of Amin (1969a; buffalofish, *Ictiobus* spp. helminths) and Mpoame and Rinne (1984; helminths of brown trout, *Salmo trutta*).

This study reports on the parasite fauna of cyprinids, ictalurids, and centrarchids that were introduced into a Colorado River reservoir. Most if not all of the parasitic taxa identified were probably introduced into the Colorado River basin with their natural fish hosts, largely from the Mississippi River Valley near the turn of the century (Minckley, 1973; Allen and Roden, 1978; Sigler and Sigler, 1987). Some remain restricted to their original hosts; others have shifted into native fishes of the region. One case is documented for transfer of a pathogenic nematode to a susceptible native species. That 7 of the 8 reported parasitic taxa have apparently not before been recorded from Arizona is an indication of the poor state of our knowledge of fish parasites in that state. The extent of dissemination of these and other parasites into native fishes is yet to be fully evaluated.

Materials and Methods

Ninety individuals of 6 fish species were trammelnetted in March 1994 from Lake Mohave, Arizona–Nevada, a narrow, 108-km-long reservoir formed on the Colorado River mainstream in the early 1950's by closure of Davis Dam. It is widest (6.4 km) in Cottonwood Basin, where collections were made, and deepest (30.5 m) at the upstream face of the dam (Allan and Roden, 1978).

Species examined were rainbow trout, *Onchorhynchus mykiss* Walbaum, total length 21–27 cm, mean 24 cm; common carp, *Cyprinus carpio* Linnaeus, 39–60, 45; channel catfish, *Ictalurus punctatus* (Rafinesque), 36–57, 46; bluegill, *Lepomis macrochirus* Rafinesque, 13–17, 15; largemouth bass, *Micropterus salmoides* (Lacèpéde), 24–43, 35; and striped bass, *Mo-*

rone saxatilis (Walbaum), 19–60, 31. Fishes were dissected at a lakeside field facility shortly after capture. Parasites were removed and fixed directly in cold ethanol/formalin/glacial acetic acid and then transported to the laboratory for routine processing and whole mounting. All parasite voucher specimens are deposited in the Harold W. Manter Laboratory (HWML), University of Nebraska State Museum, Lincoln.

Results and Discussion

Eight parasitic taxa, 7 helminths and 1 leech species, were collected from 5 of the 6 species of nonnative fishes examined (Table 1). All taxa recovered in channel catfish, bluegill, and largemouth bass naturally infect the same hosts within their native ranges in the Mississippi River and associated drainages east of the Continental Divide. All reported helminths have indirect life cycles, and finding them indicates the presence of their intermediate and other hosts in the Lower Colorado Basin. Rainbow trout, stocked by the U.S. Fish and Wildlife Service within 1 wk before sampling, were uninfected.

Atractolytocestus huronensis Anthony, 1958 (Lytocestidae Wardle and McLeod, 1952, Cestoda)

Three gravid worms infected the small intestine just posterior to the stomach of 2 common carp (Table 1). This caryophyllaeid cestode is known only from North American common carp. It was originally described in Michigan but appears widespread (Hoffman, 1967; Jones and Mackiewicz, 1969; present study). This is a new state record for Arizona. Another regional record is that of Edwards and Nahhas (1968) from the Sacramento–San Joaquin Delta, California. The presence of this worm in Arizona likely dates to the introductions of common carp just before 1885 (Taggart, 1885, and Rule, 1885, *in* Minckley, 1973).

The phylogenetic origin of *A. huronensis* is problematic considering its apparent absence in European stocks from which common carp was originally brought in 1872 from Germany into California (Allen and Roden, 1978). The few sterile testes of the parthenogenetic *A. huronensis* led Jones and Mackiewicz (1969) to imply an origin from the similar *Markevitschia sagittata* Kulakovskaja and Akhmerov, 1965, with many testes, from Amur carp, *Cyprinus carpio haemopterus* Timminck and Schlegel.

SPECIMENS: HWML Coll. No. 38728.

Corallobothrium fimbriatum Essex, 1927
Corallobothrium giganteum Essex, 1927 (Proteocephalidae La Rue, 1911, Cestoda)

Schmidt (1986) did not recognize the independent status of *C. giganteum.* Two distinct species of *Corallobothrium* Fritsch, 1886, clearly referable to *C. fimbriatum* and *C. giganteum,* nonetheless coinhabit channel catfish in Lake Mohave. The former's scolex has a collar of large lappets, proglottids considerably broader than long, and an ovary in a linear band near the posterior margin of the proglottis. The latter has a less developed fimbriate collar, proglottids far longer than broad, and a butterfly- or H-shaped ovary (Van Cleave and Mueller, 1934).

Coincident infection of channel catfish with the same 2 cestode species has been reported in the Mississippi River basin (Amin, 1991). Channel catfish, probably with their parasites, were introduced into the Colorado River basin in 1892–1893 (Worth, 1895; Sigler and Sigler, 1987) and must have been repeatedly stocked and/or translocated within the region numerous times. The recovery of these 2 species represents new state records for Arizona. Introductions and occurrences of *Corallobothrium* species in California were recorded by Haderlie (1953), Edwards and Nahhas (1968), and Hensley and Nahhas (1975) and in Texas by Underwood and Dronen (1984).

Prevalence and intensity of infection were rather high in channel catfish in Lake Mohave (Table 1). Such infections require support by stable populations of intermediate hosts (e.g., copepods and small fishes). The cestodes recovered were recently recruited juveniles and large mature adults. Development, maturation, prevalence, and intensity of infection by both cestode species appear to increase in spring and summer (Haderlie, 1953; Amin, 1991).

SPECIMENS: HWML Coll. No. 38731 (*C. fimbriatum*) and No. 38732 (*C. giganteum*).

Proteocephalus ambloplitis (Leidy) (Proteocephalidae La Rue, 1911, Cestoda)

Light infections occurred in Lake Mohave, with adults in the intestine of largemouth bass and plerocercoids in the liver of bluegill (Table 1). These are new definitive and intermediate host records for Arizona. Appearance of *P. ambloplitis* adults and/or plerocercoids in western drainages have been reported for Colorado–Utah

Table 1. Parasitic infections of Lake Mohave, Arizona, fishes, March 1994.

	Fish species (number examined)				
Parasite species	*Micropterus salmoides* (7)	*Lepomis macrochirus* (20)	*Ictalurus punctatus* (14)	*Cyprinus carpio* (15)	*Morone saxatilis* (14)
Cestoda					
Atractolytocestus huronensis	—	—	—	2 (13), 3 (0.2), 2*	—
Corallobothrium†	—	—	13 (93), 125 (8.9), 30	—	—
Proteocephalus ambloplitis	2 (29), 7 (1.0), 4	—	—	—	—
Proteocephalus ambloplitis‡	—	2 (10), 4 (0.2), 3	—	—	—
Trematoda					
Ornithodiplostomum ptychocheilus‡	—	20 (100), 14	—	—	—
Posthodiplostomum minimum‡	—	5 (25), 5	—	—	—
Nematoda					
Hysterothylacium sp.‡	7 (100), 402 (57.4), 110	—	9 (64), 278 (19.8), 146	2 (13), 2 (0.1), 1	2 (14), 2 (0.1), 1
Hirudinea					
Myzobdella lugubris	—	—	2 (14), 26 (1.9), 16	—	—

* Number of fish infected (% prevalence), number of parasites recovered (mean per examined fishes), maximum number of parasites per host.
† Includes *Corallobothrium fimbriatum* and *C. giganteum*.
‡ Larval forms in body cavity sites.

(e.g., in Colorado squawfish and possibly roundtail chub, *Gila robusta* Baird and Girard by Vanicek and Kramer (1969)). Sparks (1951), Ingham and Dronen (1980, 1982), and Underwood and Dronen (1984) have reported it in largemouth bass from Texas. Introductions of this tapeworm may date to stocking of largemouth bass, bluegill, and other sunfish from their native ranges east of the Rocky Mountains into Lake Mead and other reservoirs between 1935 and 1942 and perhaps earlier (Minckley, 1973). The presence of *P. ambloplitis* in largemouth bass and bluegill indicates the availability of crustacean intermediate hosts (cladocerans, copepods, or amphipods) at densities sufficient to sustain the worms. Pathology of plerocercoids in bluegill livers was comparable but less severe than that reported in heavier infections, as described by Amin (1990). Specimens from largemouth bass were young mature adults that were probably recruited in late winter–early spring, as previously reported by Amin and Cowen (1990) and Eure (1976).

SPECIMENS: HWML Coll. No. 38729 (adults) and No. 38730 (plerocercoids).

Ornithodiplostomum ptychocheilus (Faust, 1917) *Posthodiplostomum minimum* (MacCallum, 1921) (Strigeidae Railliet, 1919, Trematoda)

Metacercariae of these 2 trematode species were recovered from the body cavity and viscera, mostly liver, of bluegill. Infections of *O. ptychocheilus* were more prevalent and heavier than those of *P. minimum*. Metacercariae of *O. ptychocheilus* appear to belong to the new subspecies proposed by Amin (1982). Metacercariae of the latter species have also invaded a number of native fishes in Arizona (Mpoame, 1982; Mpoame and Rinne, 1983). Herons and other fish-eating birds are clearly sufficiently abundant along the lower Colorado River to sustain populations of these 2 strigeid trematodes.

The record of *P. minimum* metacercariae is, to our knowledge, the first for Arizona. Heckmann et al. (1986) reported them from woundfin in the Virgin River, Utah, a stream flowing from Utah into Arizona to enter Lake Mead in Nevada, just upstream from Lake Mohave. Metacercariae of *P. minimum* have also been reported from largemouth bass in Texas (Ingham and Dronen, 1980, 1982), and from a number of fish species in California (Haderlie, 1953; Edwards and Nahhas, 1968).

SPECIMENS: HWML Coll. Nos. 38733, 38734 (*P. minimum*) and HWML Coll. No. 38735 (*O. ptychocheilus*).

Hysterothylacium Ward and Magath, 1917 (Heterocheilidae Railliet and Henry, 1915, Nematoda)

Third-stage larvae of a species of *Hysterothylacium* were encysted in large numbers in the body cavity of largemouth bass and channel catfish but rarely in common carp and striped bass from Lake Mohave (Table 1). The first 2 fish species are well-known hosts of *Hysterothylacium brachyurum* Ward and Magath, 1917, and *Hysterothylacium spiculigerum* (Rudolphi, 1809) Railliet and Henry, 1912, in the Mississippi River basin. Worms were tightly coiled in a single plane (flat coil) within a tough hyaline cyst wall. Specimens photographed in Johnson (1980) from "bullhead catfish" and in Mitchum (1995) from largemouth bass and plains killifish are identical in appearance to Lake Mohave material; the Mitchum (1995) specimens were identified as *H.* (=*Contracaecum*) *spiculigerum*.

Introduction of these nematodes into Arizona was likely coincident with Mississippi basin fishes, as noted for other taxa. The anadromous striped bass, native to the Atlantic Coast and Gulf of Mexico, also could have transported this worm. Striped bass was first stocked in the lower Colorado River from the east in 1969 (Allan and Roden, 1978) and later from the Pacific Coast where it was introduced and established in the late 1900's (Minckley, 1973). This fish species ultimately spread to Lake Mohave, becoming abundant after 1983. This is the first published report of *Hysterothylacium* in Arizona. These nematodes appear to be widespread in nearby states (e.g., Texas [Sparks, 1951; Ingham and Dronen, 1980, 1982; Johnson, 1980]) and may be of potential public health and veterinary health importance because some *Hysterothylacium* species are capable of penetrating the alimentary tract of mammals (Deardorff and Overstreet, 1981).

SPECIMENS: HWML Coll. No. 38724–38727.

Hysterothylacium has apparently spilled over to some native and endangered fishes in Arizona. Two female Gila topminnows, *Poeciliopsis o. occidentalis* (55 mm in total length each) from Cienega Creek, Pima County (31°30′N, 110°30′W;

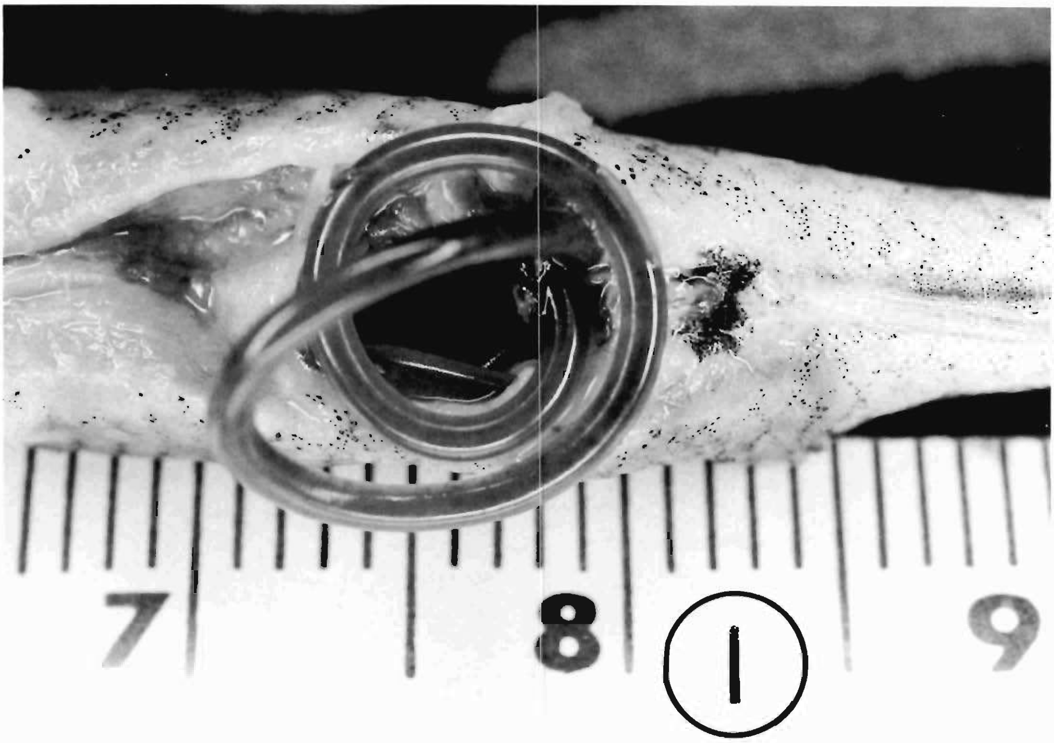

Figure 1. ***Hysterothelacium*** **sp. protruding from the body cavity through the abdominal wall of an infected** ***Poeciliopsis o. occidentalis*** **from Cienega Creek. Ruler scale in centimeters.**

Gila River basin, Santa Cruz River drainage), taken under permit to establish a captive stock, had body cavities infected with *Hysterothylacium* larvae. One had 3 nematodes in its grossly enlarged abdomen; the body wall was intact. The other carried a worm that protruded through the body wall (Fig. 1). The infection killed both topminnows. The worms were large and markedly coiled but not enclosed in any membranes. Impact of infection on small, susceptible native fishes that may be threatened or endangered cannot be overlooked in stocking and management decisions. Fisheries managers should carefully consider the potential impacts of transplanting exotic parasites.

Cienega Creek is a thermally fluctuating stream that supports only 2 other native fishes, Gila chub, *Gila intermedia* (Girard), and longfin dace, *Agosia chryogaster* (Girard) (Simms, 1991). No nonnative fishes are known in the watershed, but various centrarchids and ictalurids almost certainly live in nearby livestock-watering tanks, from which they could invade the creek. According to Simms (1991, p. 6), however, "unauthorized stockings of exotic fishes are much more likely to occur directly into Cienega Creek from sources outside the watershed . . . ." The source of infection of Cienega Creek topminnows has not been ascertained.

SPECIMENS: HWML Coll. No. 38723.

Myzobdella lugubris Leidy, 1851 (Piscicolidae, Johnston, 1865, Hirudinea)

This leech infected only channel catfish in Lake Mohave. They were in moderate numbers, usually around the mouth and on the ventral sides of paired fins. Channel catfish appear to be the preferred hosts for *M. lugubris.* At one locale in the Mississippi River basin the same leech species had infected 13 fish species, mostly centrarchids. Channel catfish were, however, the most heavily parasitized, with 185 leeches on 1 individual (Amin, 1981). Introductions of channel catfish (see earlier) were likely the principal vehicle of transmission for this parasite. This is apparently the first published record for *M. lu-*

gubris from Arizona. The same leech species is widely found on California ictalurids (Hensley and Nahhas, 1975). Material reported as *Illinobdella* sp. by Haderlie (1953, fig. 63b) from northern California catfish are likely *M. lugubris*.

SPECIMENS: HWML Coll. No. 38753.

Conclusions

Translocations of fishes and their parasites into new niches or sparsely populated waters such as those of the American West may represent serious threats to the health and survival of susceptible native fish populations. Spread of freshwater fish diseases and increased pathogenicity accompanying such introductions is of growing concern (Bauer and Hoffman, 1976; Bauer, 1991; Kennedy, 1993). Fish parasites are readily transferred with their hosts (e.g., catfishes, carps, basses, sunfishes), and some parasite taxa have substantially expanded their ranges due to increasing aquaculture and expanding sport fisheries (Hoffman, 1970).

The parasite fauna from our sample of introduced fishes does not appear as rich compared to that reported from the same hosts in the Mississippi River basin. The phenomenon of reduced parasite diversity in introduced-fish assemblages was first noted by Dogiel (1948). Parasites introduced into a new area without an ability to infect indigenous fishes can be disseminated if their introduced hosts are dispersed by human manipulation (Kennedy, 1994). Among other factors, reduced parasite diversity in introduced assemblages of fishes may also result from intentional or chance introduction of uninfected hosts into new habitats or an inability on the part of parasites species-specific to native-fish hosts to infect new, alien taxa, or both.

Notable by their absence from our Lake Mohave samples are acanthocephalans. Barriers to their establishment may include (1) their tendency for narrow specificity in intermediate hosts, (2) general absence or occurrence below threshold levels, necessary to sustain a viable worm population, of amphipod or isopod intermediate hosts (no native amphipods or isopods are know from this area), and (3) times of host introductions not coinciding with natural infective seasons during which generation cycle/recruitment occurs. The transmission window for these parasites may thus be seasonally restricted. Kennedy (1994) noted a similarly conspicuous absence of acanthocephalans among fish parasites colonizing the British Isles.

Dispersal success of an introduced parasite depends on its reproductive potential, degree of host specificity, availability of appropriate or ecologically equivalent intermediate hosts, and time of introduction. A generalist should be better able than a specialist to invade and colonize new habitats. Among the parasites recorded in Lake Mohave, *P. ambloplitis* may be such a generalist. Despite a complex life cycle, it has broad specificity in each host category used (Amin, 1990; Amin and Cowen, 1990) and has succeeded in dispersing widely. Hoffman (1970, p. 77) reported its successful spread from "East to Midwest to the state of Washington in largemouth black bass."

Clearly, species of the nematode genus *Hysterothylacium* are also successful, infecting a number of Lake Mohave fish species and often occurring in large numbers (Table 1). This suggests an efficient generalist. Under such conditions, a native fish like the Gila topminnow need not be related to the parasite's original host to experience interspecific transfer and ultimately suffer death. Introduced parasites like *Hysterothylacium* that use many taxa of intermediate hosts are likely to establish readily. Intermediate invertebrate hosts such as copepods, cladocerans, and oligochaetes (Bauer, 1991) lending themselves to support such parasite taxa are often cosmopolitan in distribution.

A host-specific parasite may be ill-adapted for successful invasion because its dispersal may be sorely limited by the restricted distribution of its host. *A. huronensis* is a potential example in Lake Mohave because it is host-specific in common carp. Obviously, the potential restriction is far outweighed by the great dispersal and reproductive capabilities of the host and because *A. huronensis* is triploid with a stable, parthenogenetic reproductive cycle capable of sustaining it under conditions of host rarity (Jones and Mackiewicz, 1969). Oligochaete (tubificid) intermediate hosts must be present in Lake Mohave for *A. huronensis* to occur and persist but, again, those invertebrates are consistent in reservoir benthos, in Arizona (Rinne, 1973) and elsewhere. Other relatively host-specific cestodes include *C. fimbriatum* and *C. giganteum,* restricted to the narrow choice of ictalurid catfishes. Again, the great dispersal abilities of those hosts, albeit often through artificial human translocation, have

vastly enhanced the tapeworm's success at invading new habitats.

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